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Asbestos Fiber Concentrations in the Drinking Water of Communities Using the Western Arm of Lake Superior as a Potable Water Source

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ASBESTOS FIBER CONCENTRATIONS IN THE DRINKING WATER OF COMMUNITIES USING THE WESTERN ARM OF LAKE SUPERIOR AS A POTABLE WATER SOURCE

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16. ABSTRACT

Suspended solids data and asbestos fiber concentrations are presented as measured by X-ray diffraction and electron microscopy of potable water supply samples collected from around the western arm of Lake Superior during the fall of 1973. The data show a trend of decreasing concentrations as one proceeds from Silver Bay in a counterclockwise manner around the western arm of the Lake. A qualitative agreement between concentrations measured by X-ray diffraction and by transmission electron microscopy is apparent.

17. KEY WORDS AND DOCUMENT ANALYSIS

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INTRODUCTION

Carcinogenic activity has been associated with asbestos fibers by many investigators (1). This fact together with the discovery (2) that suspended solid material in the water in the western arm of Lake Superior contains asbestos fibers were major reasons the Region V, U.S. Environmental Protection Agency decided to initiate the Lake Superior Asbestos Study. This study (3) was planned and is being carried out by personnel in the Surveillance and Analysis Division to: (1) Determine concentrations of asbestos fibers in the water and air around the western arm of Lake Superior. (2) To measure the amounts and characteristics of asbestos fibers in potable water intakes (PWI) using Lake Superior water as their source; (3) to provide background data to support estimates of future use of Lake Superior water for human consumption and (4) to measure the environmental effects should all industrial discharges into the Lake be terminated. The present communication is restricted to the potable water intake investigation. Other parts of the study will be reported as additional analytical results are accumulated and evaluated.

THE STUDY PLAN

The study plan called for twelve weekly surveys of potable water intakes around the western arm of Lake Superior (3). These were completed during the Fall of 1973.

At each of the stations a 250 ml, 1/2 gal and 5 gal sample was collected. No preservative was used but all 250 ml samples were filtered within 24 hours after sample collection. The 1/2 gal samples were stored and were to be used only if additional analyses were requested at a later date. Five to ten liters of the 5 gal samples were filtered under air pressure through a tared 0.45 u millipore filter and the residue analyzed for suspended solids and for mineral content by x-ray diffraction. A 200 ml aliquot from the two hundred and fifty milliter samples were vacuum filtered through a 0.1 u millipore filter and the residue analyzed for fiber content using an electron microscope. Suspended solids, amphibole by x-ray diffraction, amphibole and chrysotile fiber number and mass concentrations by electron microscopy were measured on each sample. In addition the length and width of each fiber seen with the electron microscope was measured and reported.

Figure 1 gives a detailed description of each sampling station.

Figure 1

U.S. EPA Region V Lake Superior Asbestos Study PWI Stations

1. Thunder Bay, Ontario - tap on outside of south side pumping building, incoming raw water.

2. Grand Marais, Minnesota - water plant intake from the tap behind the wet well pump.

3. Silver Bay, Minnesota - water plant pump house tap off intake line after pump.

4. Beaver Bay, Minnesota - water plant incoming pipe to right side of filter tanks.

5. Two Harbors, Minnesota - water plant intake

6. Duluth, Minnesota - raw water intake laboratory tap of Lake Wood Pumping Station.

7. Cloquet, Minnesota Water Line - small pump tap in the Stock Pumping Station.

8. Ashland, Wisconsin - intake well tank on 12th Avenue, East Ashland.

9. Ontonagon, Michigan - tap from raw water intake line in basement of water plant.

10. Eagle Harbor, Michigan - tap on top of pump at the water plant pump house.

11. Marquette, Michigan - tap on sink in basement of Lake Shore Drive water plant.

12. Superior, Wisconsin - tap after pump inside Minnesota Point Pumping Station.

Figure 2 shows the relationship of the stations to the currents in that area of the Lake. The order of the stations will remain the same for all subsequent data presentation; namely from the North West shore of the Lake down current as shown in the figure.

In addition to sample analytical data weather stations were established at Grand Marais, Duluth and Ontonagon which measured precipitation, wind speed, wind direction and air temperature.

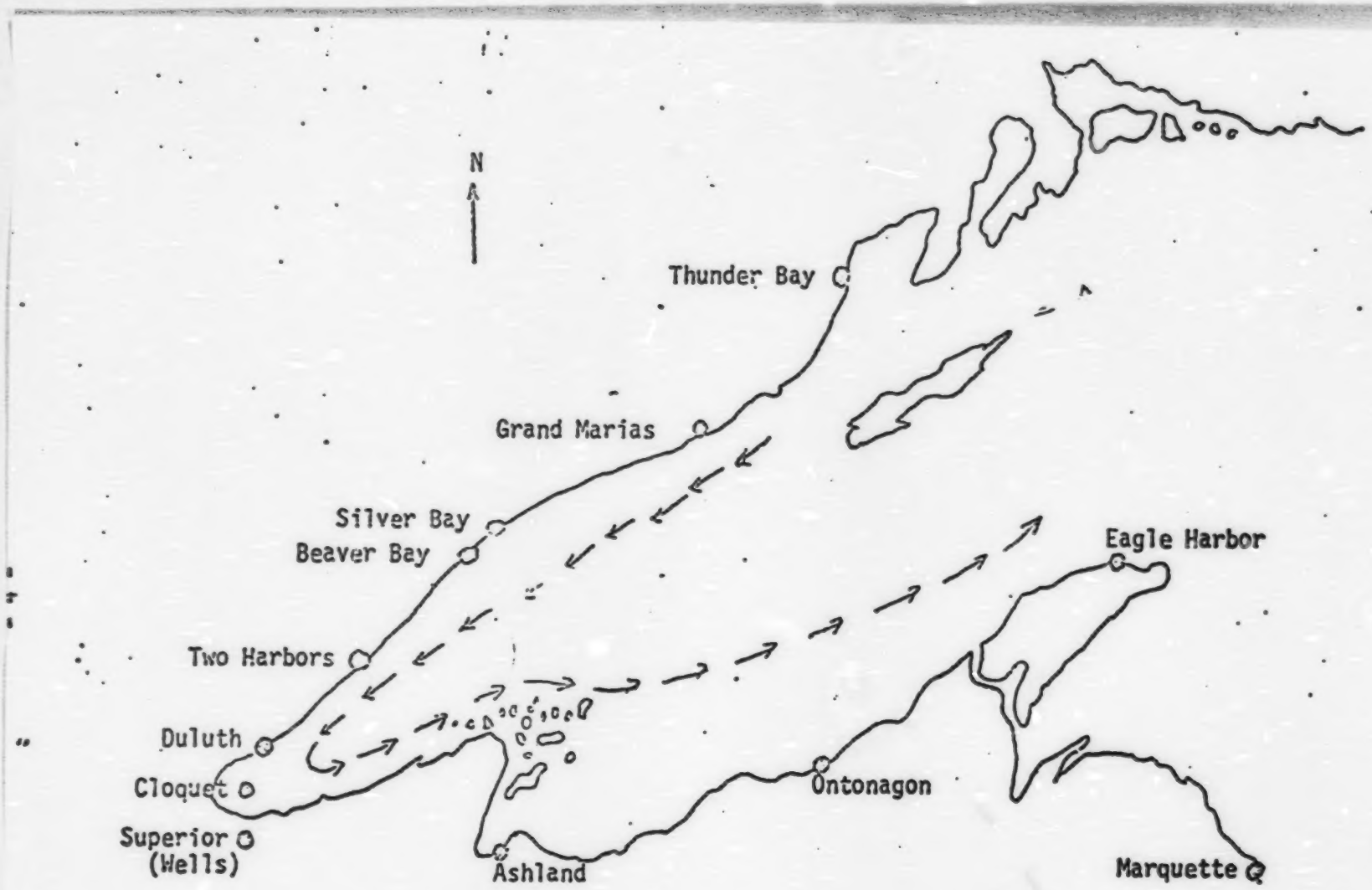

FIGURE 2

Map of Lake Superior showing the Lake currents, and the Region V sampling stations.

FIGURE 3

Suspended Solids Data

Figure 3 is a summary of suspended solids data. The concentrations vary with both location and time and we were not able to detect a relationship between suspended solids concentrations and asbestos fiber concentrations.

Milligrams of Suspended Solids Per Liter of Water (1973)

	8/22	8/29	9/6	9/14	9/19	9/26	10/3	10/10	10/17	10/24	10/31	11/14	11/28
Thunder Bay	0.63	1.15	0.96	1.21	0.92	0.95		0.98	1.01	0.79	0.94	0.79	1.09
Grand Marais	0.58	0.50		0.24	0.33	0.69	0.52	0.50	0.22	0.59	0.33	0.55	0.47
Silver Bay	0.48	0.44	0.24	0.20	0.22	0.39	0.48	0.96	0.25	0.50	0.63	0.45	0.34
Beaver Bay	1.19	1.15	6.03	0.40	0.92	1.17	0.56	1.19	0.40	0.92	2.94	1.01	0.45
Two Harbors	0.94	0.84	0.81	0.78	0.94	0.71	0.93	1.82	0.65	0.76	0.84	1.65	1.09
Duluth	1.10	0.33	0.43	0.82	0.86	0.54	0.45	1.16	0.92	0.68	0.63	0.86	0.73
Cloquet Water Line	1.31	0.61	3.36	1.92	1.66		2.79	1.22	1.51	1.30	2.52	8.10	4.93
Ashland	3.33	2.48	4.50	3.09	3.02	4.11	1.82	3.85	3.85	2.92	5.58	2.90	2.43
Ontonagon	1.49	0.60	0.89	1.22	2.02	1.25	1.63	0.82	2.73	1.18	1.02	1.09	1.13
Eagle Harbor	0.48	0.60	1.55	0.76	0.95	3.31	0.41	0.28	0.76	0.56	0.18	0.80	0.57
Marquette	0.33	0.31	0.36	0.31	0.31	0.63	0.51	0.43	0.45	0.73	0.49	0.32	0.55
Superior (Wells)	0.85	1.60	0.82	1.22	2.07	0.57	0.78		9.85	1.01	0.66	1.73	1.10

Figure 3

The next figure (4) shows the concentrations of amphibole asbestos found using x-ray diffraction techniques (3). The analyses of these samples were carried out by a group working at the National Water Quality Laboratory in Duluth and under the direction of Dr. Phil Cook.

Milligrams of Amphibole Particles Per Liter of Water by X-Ray Diffraction

1973

	8/22	8/29	9/6	9/14	9/19	9/26	10/3	10/10	10/17	10/24	10/31	11/14	11/28
1. Thunder Bay	<0.01	0.01	0.02	0.01	0.01	0.02		0.01	0.01	0.01	0.03	0.02	0.01
2. Grand Marais	0.01	<0.01		0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.01	<0.01
3. Silver Bay	0.01	0.01	<0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.27	0.05	0.02
4. Beaver Bay	0.32	0.27	4.03		0.28	0.29	0.05	0.12	0.12	0.30	1.78	0.37	0.12
5. Two Harbors	0.12	0.12	0.28	0.17	0.11	0.06	0.07	0.03	0.14	0.18	0.14	0.09	0.18
6. Duluth	0.12	0.08	0.10	0.06	0.15	0.10	0.06	0.02	0.06	0.04	0.06	0.08	0.26
7. Cloquet Water Line	0.02	0.05	0.16	0.01	0.08		0.10	0.03	0.06	0.03	0.03	0.14	0.02
8. Ashland	0.02	0.01	<0.02	0.02	<0.02	0.08	0.02	0.04	<0.02	<0.02	0.03	<0.01	<0.01
9. Ontonagon	0.01	0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
10. Eagle Harbor	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
11. Marquette	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
12. Superior (Wells)	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01		<0.05	<0.01	0.01	<0.01	<0.01

Figure 4

The graph shown in Figure 5 has been constructed using the data shown in the previous figure. To obtain the graphed values all data points from a given sampling station were summed and the sum divided by the number of samples.

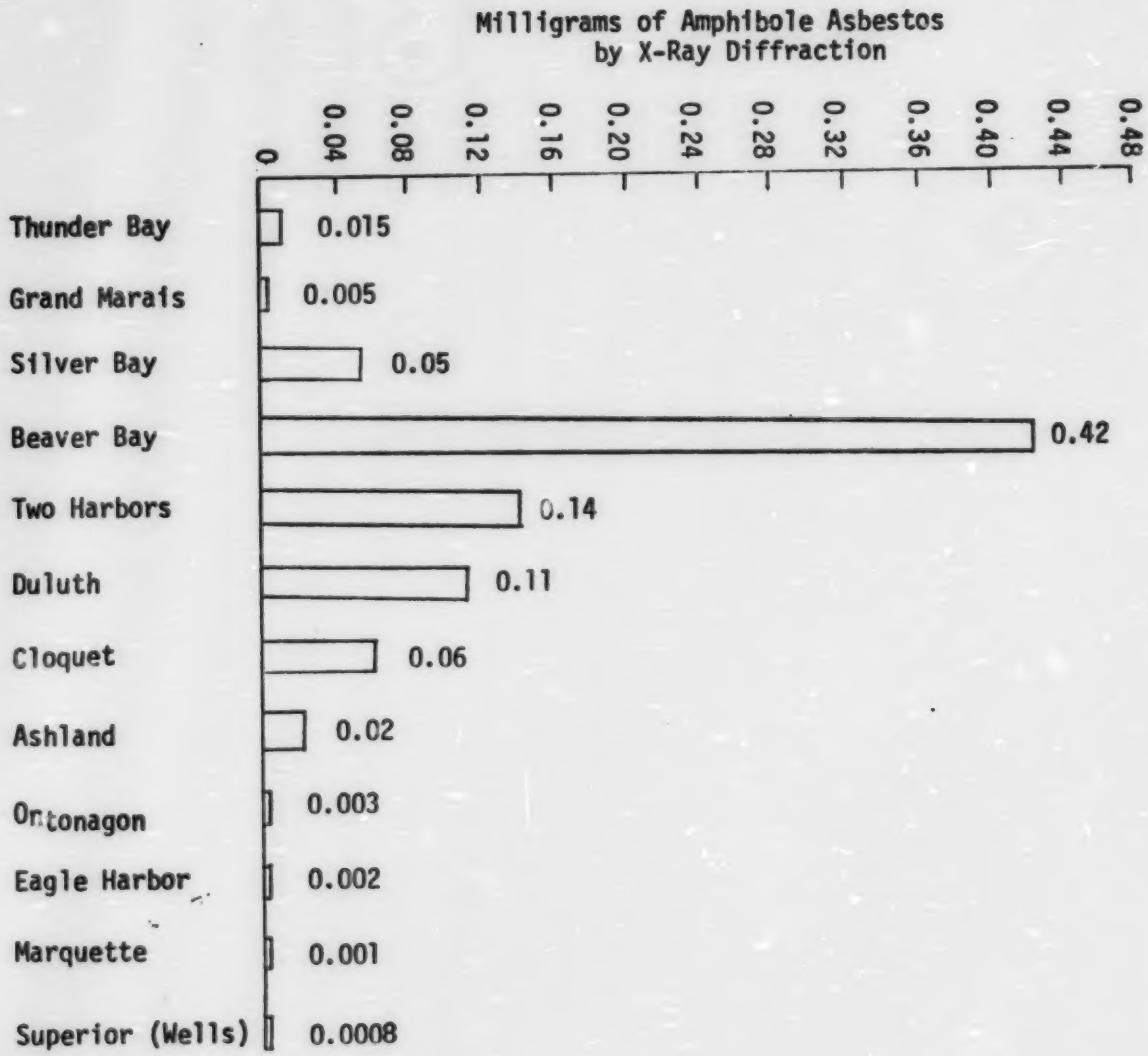
Milligrams of Amphibole Asbestos
by X-Ray Diffraction
0
0.04
0.08
0.12
0.16
0.20
0.24
0.28
0.32
0.36
0.40
0.44
0.48
Thunder Bay
0.015
Grand Marais
0.005
Silver Bay
0.05
Beaver Bay
0.42
Two Harbors
0.14
Duluth
0.11
Cloquet
0.06
Ashland
0.02
Ontonagon
0.003
Eagle Harbor
0.002
Marquette
0.001
Superior (Wells)
0.0008

Figure 5

Figure 6 is a table listing concentrations of amphibole fibers as determined by two different electron microscope laboratories (4, 5) the starred values were reported by McCrone Associates and the unstarred values by the Ontario Research Foundation. Additional samples were collected in the Spring of 1974 at Grand Marais, Silver Bay, Beaver Bay, Two Harbors and Duluth. We have chosen to call a particle having a width equal or less than 1/3 its length a fiber.

Million Amphibole Asbestos Fibers Per Liter of Water
as Measured by Electron Microscophy during 1973

	PWI	8/22	8/29	9/6	9/14	9/19	9/26	10/3	10/10	10/17	10/24	10/31	11/14	11/28
1.	Thunder Bay	0							*0	*0.59	*2.1		*0	
2.	Grand Marais	*0	0				0.26	*0	*0	0.03	*0.12		*0	**
3.	Silver Bay		0.18		0	0.17	*0.14	*0	*0.46	*0.46	*0.08		*0.80	**
4.	Beaver Bay	*8.5	5.10		0.17			*1.2	*2.4	*6.6	*0.65		*59	**
5.	Two Harbors	*5.0	*4.4			1.1				*1.6	*3.0			**
6.	Duluth	*4.6					*2.2	*1.1			*1.9		*0.1	**
7.	Cloquet Line	*1.8	*0.8				*0.8	*1.8	*0	*0.9	*1.1			
8.	Ashland	*0		0	0.19		*0.25	*0.62	1.63	*0	*0		*0.06	
9.	Ontonagon	0.70				0		*0.48	0	*0				
10.	Eagle Harbor	0			0.17	0.18	*0.42	*0.08	0	*0	*0.16			
11.	Marquette	0.19						*0	0.27	*0.17				
12.	Superior, Wis. deep wells	*0	*0				*0.1	*0			*0.08		*0	

Figure 6

*Samples reported by McCrone Associates

As with the x-ray diffraction data the results from the EM experiments may be shown in bar graph form as seen in the next figure (7).

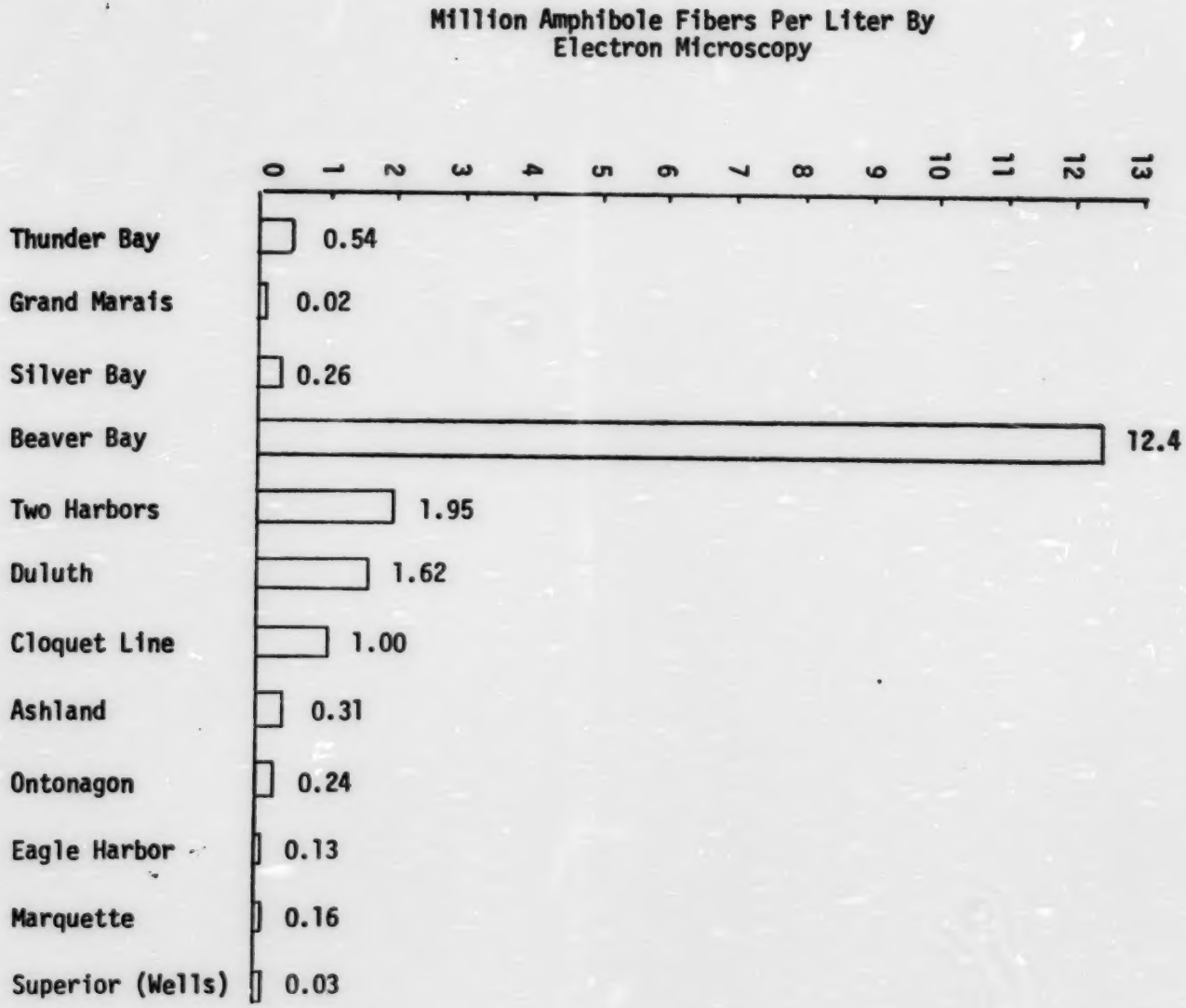
Million Amphibole Fibers Per Liter By
Electron Microscopy
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Thunder Bay
0.54
Grand Marais
0.02
Silver Bay
0.26
Beaver Bay
12.4
Two Harbors
1.95
Duluth
1.62
Cloquet Line
1.00
Ashland
0.31
Ontonagon
0.24
Eagle Harbor
0.13
Marquette
0.16
Superior (Wells)
0.03

Figure 7

The graphed values were obtained by averageing all sample concentrations reported by both contracting laboratories from each sampling station. The similarity between the electron microscope data from the two different contracting laboratories and between the x-ray diffraction and electron microscope summary graphs gives us a considerable amount of confidence that our analytical approach is fundamentally sound.

Figure 8

(during talk Figure 8 will be an overlay of Figure 5 and Figure 7)

Figure 9 is a graph of fiber mass as calculated from electron microscope measurements of each individual fiber length and width. Although the mass data shows more scatter than the number concentration data, the trends are the same as those shown on the previous slides.

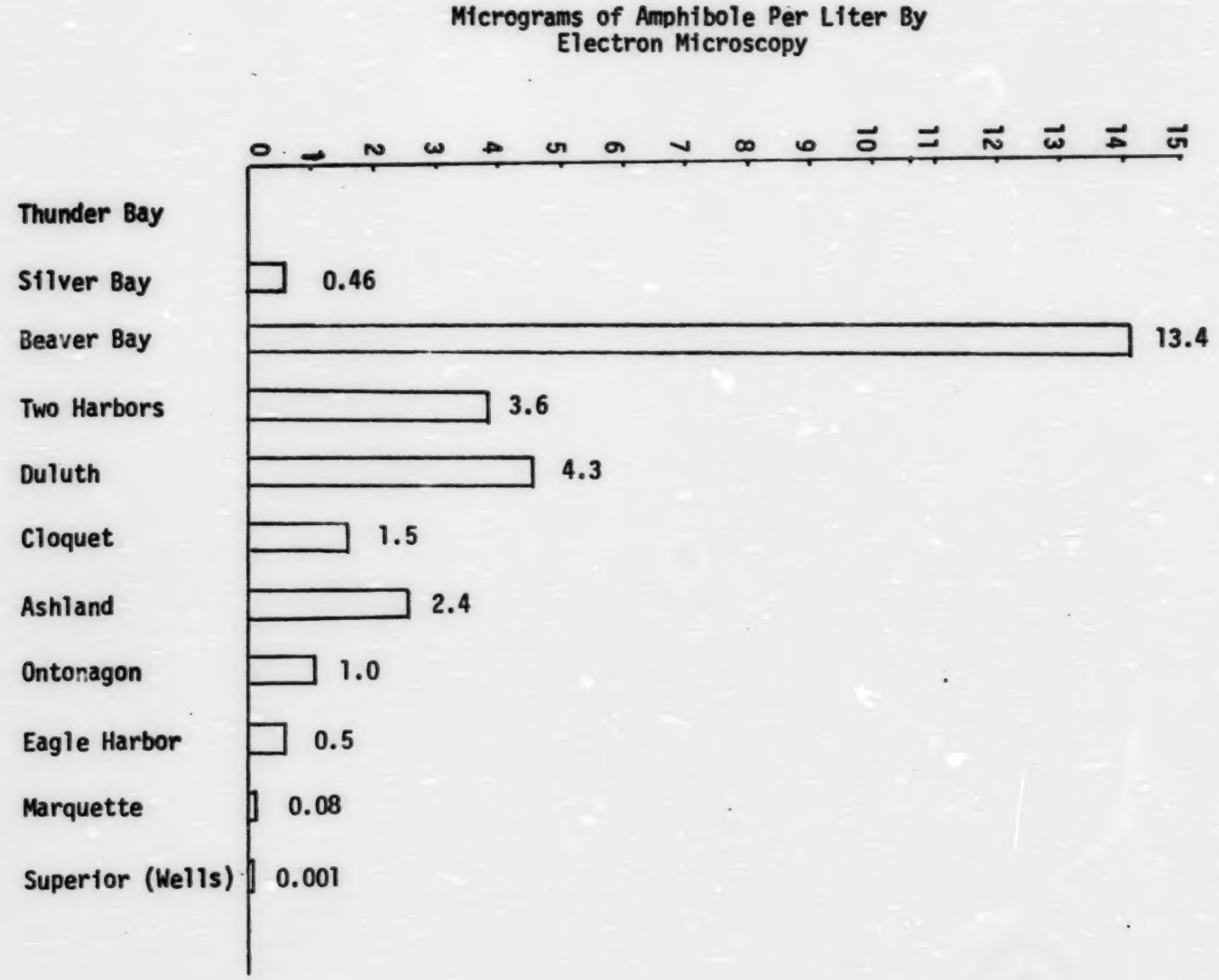
Micrograms of Amphibole Per Liter By
Electron Microscopy
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Thunder Bay
Silver Bay
0.46
Beaver Bay
13.4
Two Harbors
3.6
Duluth
4.3
Cloquet
1.5
Ashland
2.4
Ontonagon
1.0
Eagle Harbor
0.5
Marquette
0.08
Superior (Wells)
0.001

Figure 9

In summary the data confirms a relationship between asbestos concentrations measured by x-ray diffraction and electron microscope techniques for this area of the environment. There appears to be no relationship between suspended solids concentrations and the number of asbestos fibers found in the different samples and finally, the analytical procedures are clearly sufficient to differentiate between samples from polluted and non-polluted sources.

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